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COMPUTERIZED ULTRASONIC IMMERSION INSPECTION SYSTEM

Report No 85-284-K

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ABSTRACT

This report describes a system developed for performing ultrasonic inspection using a Krautkramer-Branson KB6000 ultrasonic instrument and an Apple II+ microcomputer. The system was developed in the Research Division primarily for laboratory use.

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EXECUTIVE SUMMARY

COMPUTERIZED ULTRASONIC IMMERSION INSPECTION SYSTEM

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An ultrasonic immersion tank inspection system has been developed at the Research Division for laboratory use. This system is based on a KB6000 ultrasonic instrument and an Apple II+ microcomputer and uses stepping motors to scan an ultrasonic probe across the test piece. A variety of scans are possible and can be displayed in colour on a colour monitor or stored on disk. Hard copy output is also available in either black and white or colour.

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To Mr. F.J. Kee
Director of Research

COMPUTERIZED ULTRASONIC IMMERSION INSPECTION SYSTEM

1.0 INTRODUCTION

During the past five years, there has been very rapid development in the area of microcomputer technology. During this time there has also been an on-going effort at the Research Division to apply this emerging technology to ultrasonic testing. This has resulted in the development of a user-friendly microcomputer based inspection system which has proven itself in many applications. Since it has been developed and applied concurrently, it has had the opportunity of going through many design iterations in which many useful features have been added. The success of this system is demonstrated by the fact that most of the ultrasonic inspection done at the Research Division is now handled by this system. This report provides a brief description of the system hardware and software.

2.0 SYSTEM HARDWARE

The system hardware consists of the following components as illustrated in Figure 1.

Krautkramer-Branson KB6000 ultrasonic instrument 4-channel with digital computer interface

Apple II+ microcomputer with autostart ROM, two disk drives with DOS 3.3, colour CRT monitor, and a dot matrix graphics printer

Interactive Structures DI09 parallel interface card

Center Computer Consultants 15V 15Amp "Big Stepper" stepping motor driver with Apple interface card

Dropping resistor module (for above item)

Immersion tank with X-Y probe positioner driven by two Superior Electric "Slo-Syn" M091-FD06 stepping motors (Figure 1 shows only one of them)

Hewlett-Packard 7470A two colour digital plotter with serial RS-232 computer interface

Serial RS-232 interface card for the Apple (for above item)

3.0 SYSTEM INTERFACING

The interface between the KB6000 and the Apple is based on the digital computer interface module available from Krautkramer-Branson for the KB6000. This module is a parallel interface with 16 digital input lines, 16 digital output lines, and 4 data transfer control lines. All 32 data lines are connected directly to the DI09 interface card together with two of the data transfer control lines. The other two control lines are connected directly to the "game I/O" connector in the Apple. This interface allows all of the normal computer interface features of the KB6000 which includes control over gain, frequency, pulsing, gate delay range & threshold, and data acquisition for signal amplitude and distance.

The interface for the stepping motors is supplied with the driver. It is a direct parallel interface with two dedicated output bytes, one for each motor. The first four bits in each byte correspond to the four coils in the motor. When a bit is high, the corresponding coil is energized.

The dot-matrix printer comes with its own interface card while the digital colour plotter uses a standard RS-232 serial interface.

4.0 RESOLUTION

On both the X and Y axes, the leadscrews give 0.001" for each stepping motor step.

For black and white images, the Apple graphics screen has a resolution of 280 X 192 pixels. This is reduced to 140 X 96 to allow the use of 12 different colours in addition to black, white, and gray.

5.0 SYSTEM OPERATION

5.1 A-scans

An A-scan is a time-amplitude plot of the received ultrasonic signal and normally appears on the CRT screen of an ultrasonic instrument. The rectified A-scan can be digitized by the KB6000 and displayed on the Apple CRT monitor. This is done by setting the gate via the computer to the beginning of the location to be digitized. The computer then increments the gate from each

location to the next by an amount corresponding to the gate width selected. At each location, the maximum amplitude in the gate is digitized and sent to the computer. A hard copy of the A-scan can be quickly made on the dot-matrix printer. Figure 3 shows an A-scan from the ASME block shown in Figure 2.

5.2 B-scans

A B-scan is a two dimensional image corresponding to a cross-sectional view through the test-piece. This image is generated from 96 consecutive A-scans which are digitized according to the above description. They are then processed into multi-colour raster lines with a set of thresholds so that each colour represents a specific range of amplitudes.

To generate the B-scan image, the operator, after setting up the immersion tank and selecting the correct software, selects the desired gate range (width), starting location and probe increment. Since the gate range selected is equal to the gate delay increment, a larger gate range will increase the depth of the scan in the material, while a smaller one will provide higher resolution. Both of these parameters are entered via the computer keyboard. The operator then pushes the "S" key and the computer begins the scan. After the gate is scanned through each A-scan, the stepping motor moves the probe to the next location. This is repeated until all 96 raster lines have been generated and the image is complete. One such image can be generated in as little as 12 seconds (Figure 4). When B-scans are done with angle beam probes, a skewed image results, however, software has been written which normalizes these skewed images.

5.3 C-scans

C-scans provide a plan view of ultrasonic reflections in a test-piece. Here the gate location is kept fixed but the probe is moved along the X and Y axes to cover an area. User-friendly displays using colour graphics make it easy for the operator to choose the threshold levels and associated colours, scan distances, and motor speed. Scan speeds of up to 1"/sec are readily achievable. To achieve the higher speeds without slipping, it is necessary to give the stepping motors a controlled acceleration and deceleration. This function is handled by the software. To insure the uniformity of the scan, data acquisition is done only during constant motion.

These scans are normally colour coded according to signal amplitude. However, a variation of the scan program colour codes according to the gate which has a signal above threshold. Up to eight gates can be set for these scans. This makes it possible to colour code according to the distance to the first signal above threshold. (Due to the automatic gain control, the

distance data available from the KB6000 gives a measurement to the largest signal in the gate instead of the first one above threshold.) Since the gate settings are stationary throughout the scan, they are set by the operator via the front panel of the KB6000.

The operator may at any time stop the scan. With the scan stopped, he can, with push-button control via the keyboard, move the probe along the X and Y axes at high speed or low speed. If the operator wishes, he can resume the scan, in which case the computer will automatically move the probe back to the position where it was when the scan stopped, and then resume scanning. Alternatively he can instruct the computer to go back to the starting location and repeat the scan. A flashing cursor can also be selected to indicate the position of the probe relative to the C-scan image.

Hard copies of B-scans and C-scans can be made in black and white on the dot matrix printer, or in full colour on the colour plotter. While the colour plotter can only hold two pens at a time, the full range of colours can be achieved by switching pens. The software tells the operator when to switch the pens, and which colours to use. A colour plotted conventional C-scan image is shown in Figure 5.

6.0 ACKNOWLEDGEMENTS

The author wishes to express his appreciation to Mr. Tony Allen for his extensive contributions to the system development in the form of many helpful suggestions from the perspective of the user.

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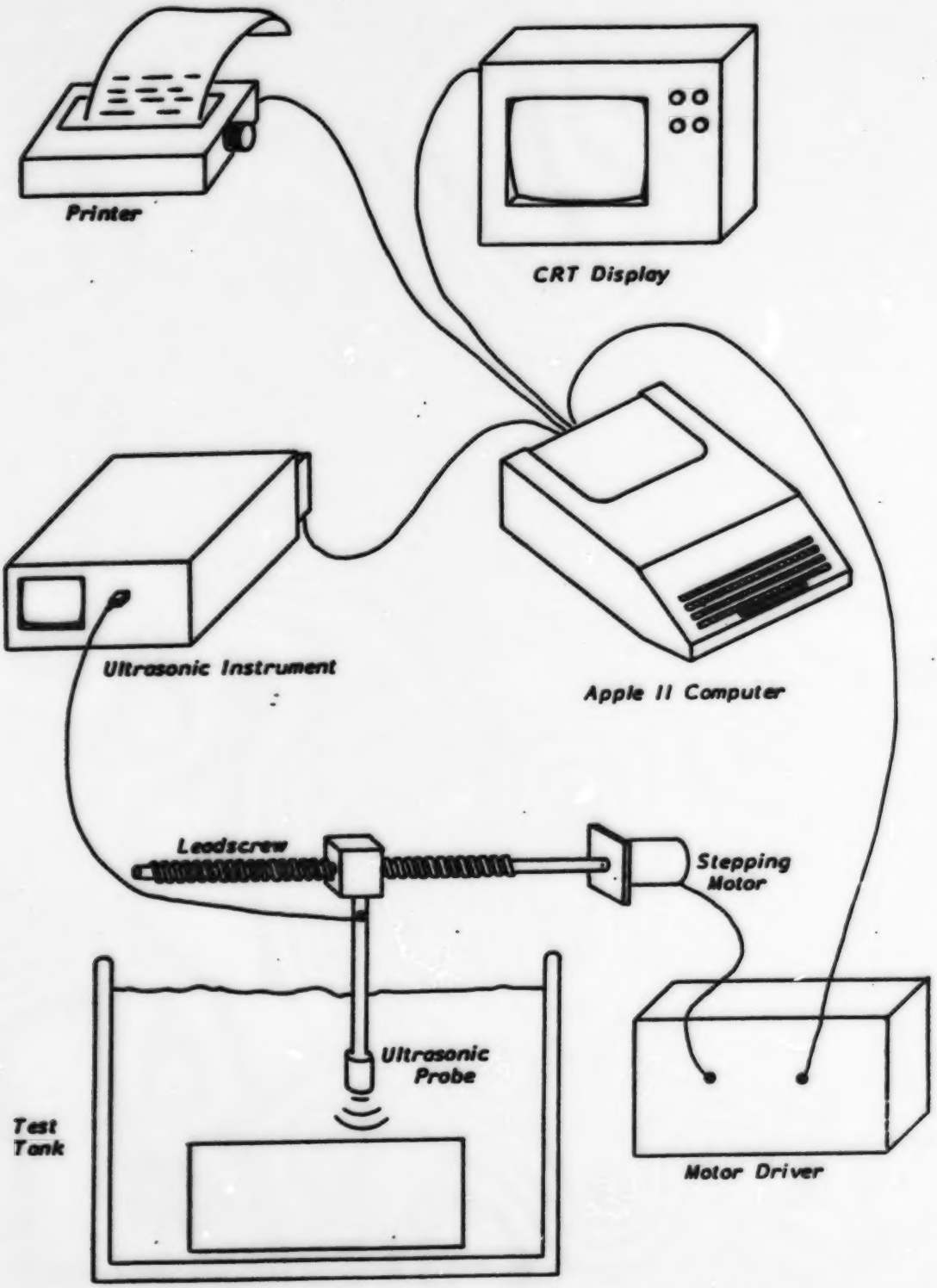

FIGURE 1

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FIGURE 2
ASME BLOCK WITH SIDE-DRILLED HOLES

A - SCAN

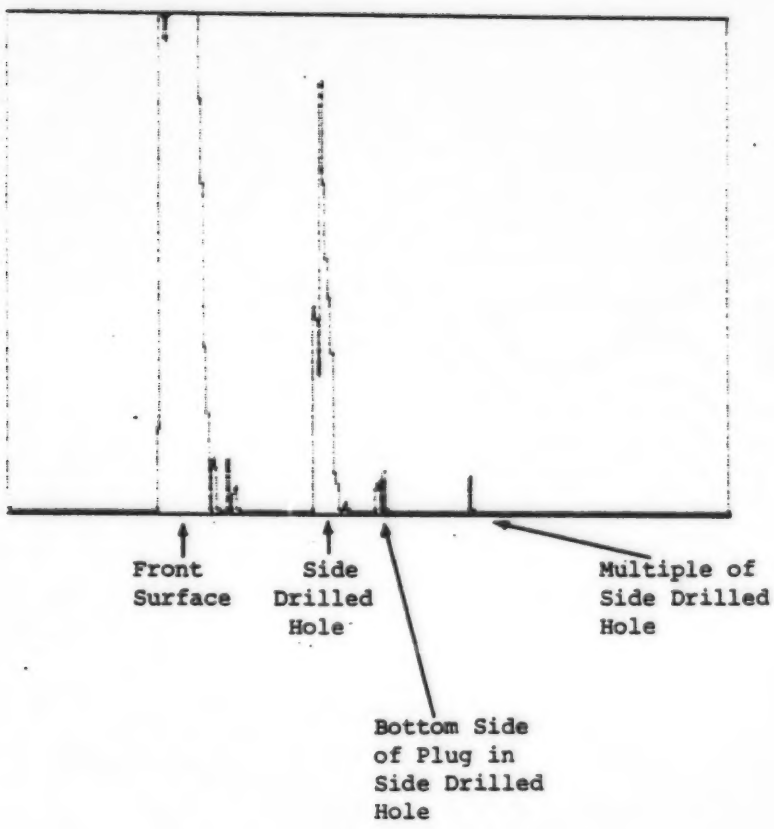

FIGURE 3
A - SCAN ON ASME BLOCK

B - SCAN

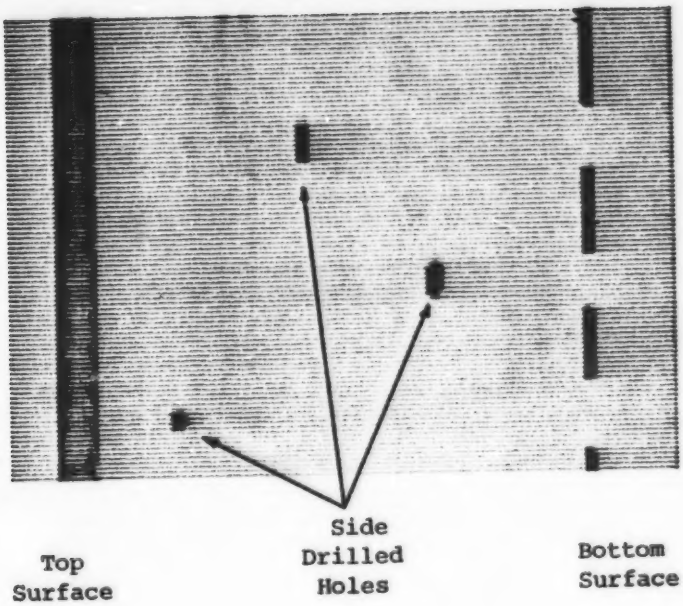

FIGURE 4
B - SCAN OF ASME BLOCK

C - SCAN

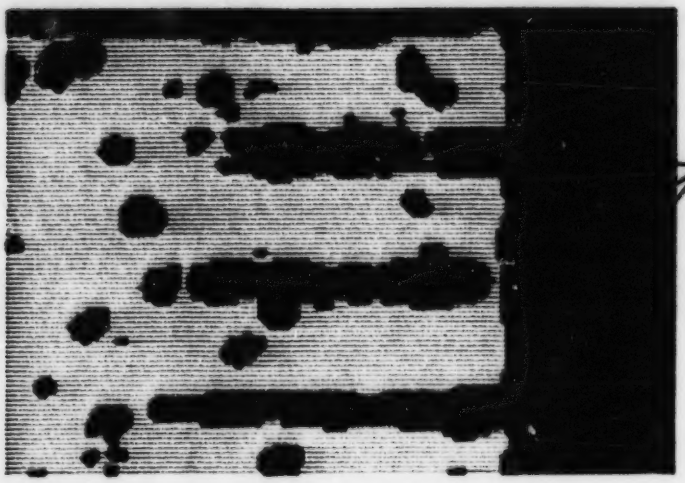

FIGURE 5
C - SCAN OF ASME BLOCK